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Errata

Page 3	1st column, para 2, line 2, to read permettrait
Page 3	1st column, para 2, line 7, to read contrôle
Page 4	2nd column, para 2, line 3, to read homogeneous
Page 4	2nd column, para 3, line 6, to read garlic
Page 5	1st column, para 2, line 5, to read effect
Page 5	last line, to read analysis
Page 6	abbreviation Me Br to read Methyl bromide
Page 6	Table 3, line 1, to read INTERACTION
Pages 7 & 8	1st line of Tables 4, 5, 6, 7 & 8, to read INTERACTION
Page 8	ACKNOWLEDGEMENTS, line 1, to read following
Page 10	1st column, para 4, line 14, to read wettable
Page 10	2nd column, para 4, line 10, to read down
Page 11	1st column, para 1, line 14, to read biological
Page 11	1st column, para 3, line 4, to read DDT
Page 12	Safety intervals for Baythroid 0.50 SL (5%) and Cymbush 10% E.C. to read 7 and 4 respectively.
Page 14	1st column, para 1, line 6, to read "must rest on"
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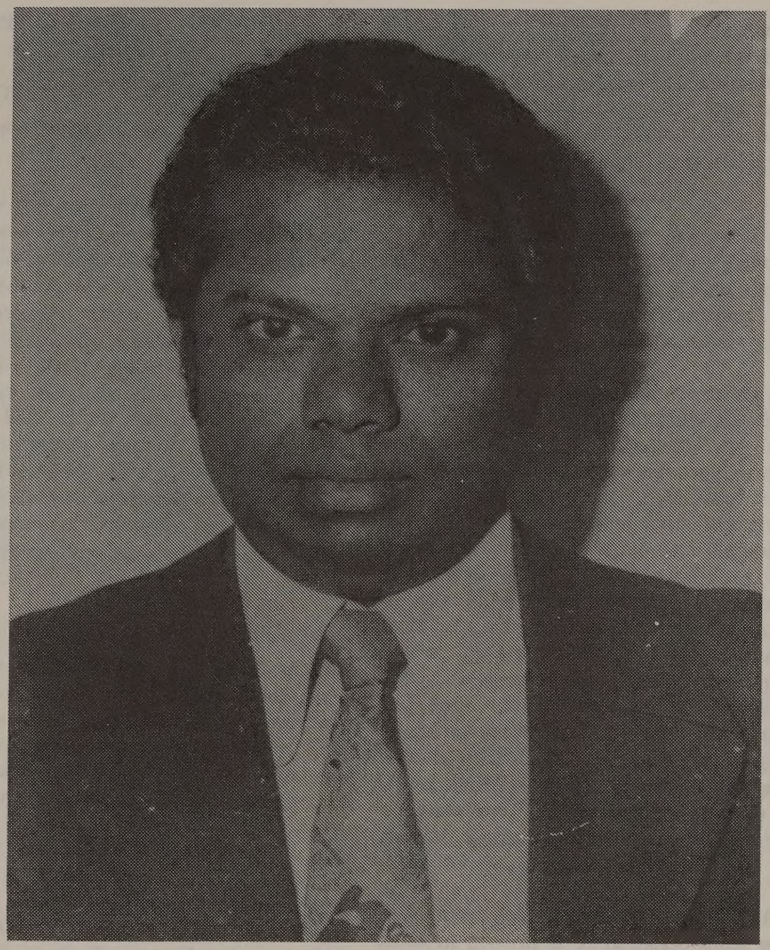
Page 15	2nd column, para 2, line 3, to read two species
Page 16	1st column, para 6, line 2, to read affect citrus
Page 16	2nd column, para 2, line 2, to read occasional
Page 16	2nd column, para 3, line 2, to read between
Page 17	2nd column, para 6, line 1, to read (mainly houseflies)
Page 17	2nd column, para 6, line 5, to read cleanliness
Page 18	2nd column, para 2, line 2, to read occurring
Page 18	2nd column, para 3, line 2, to read and
Page 18	2nd column, para 4, line 3, to read serious
Page 18	2nd column, para 5, line 3, to read Ministry
Pages 19 & 20	Safety intervals for Decis, Cymbush and Baythroid to read 2, 4 and 7 respectively.
Page 21	1st column, para 1, line 8, to read projects
Page 21	1st column, para 6, line 3, to read groundnuts
Page 22	1st column, line 9, to read reliability
Page 25	2nd column, para 4, line 2, to read Fisheries



IN MEMORIAM

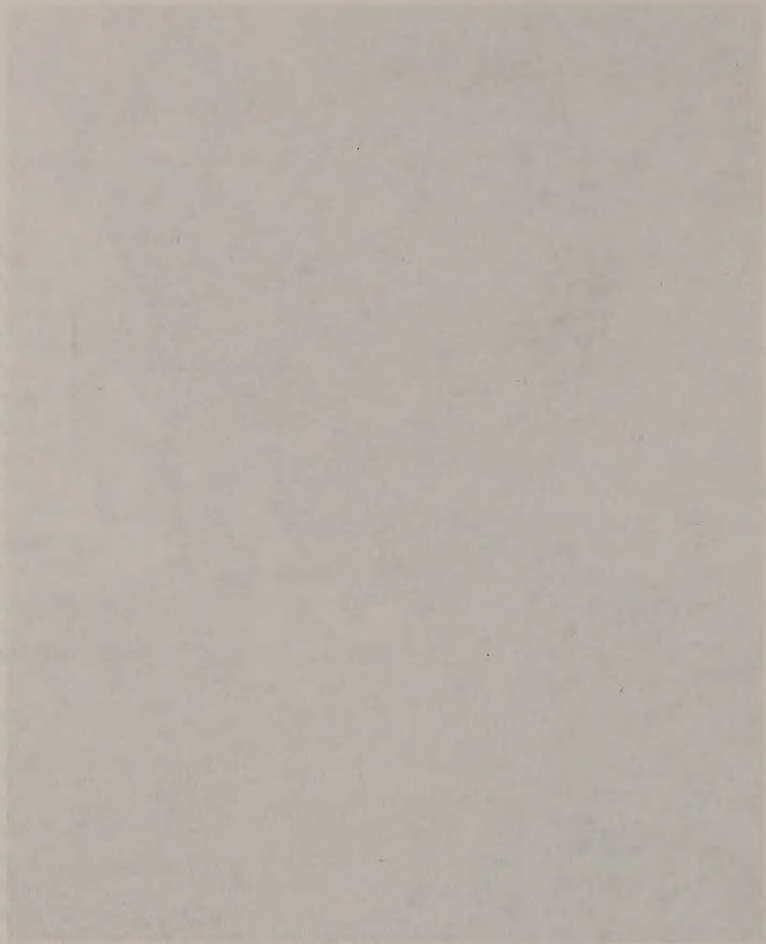
SOOCRAMANIEN PILLAY MAUREE.
B.Sc. (Agr.), M. Agr. St.

The news of the passing away of Mr. S. P. Mauree on Sunday 14th August, 1988, at the age of 44, came as a shock to his friends and colleagues of the Agricultural Services.

As Head of Division of the Extension Services Mr. Mauree had friends not only in the various divisions of the Agricultural Services but also among farmers, big and small, throughout the Island.

His brilliant interventions at seminars and meetings were always well accepted because he had a thorough knowledge of his subject. His reflexions and criticisms in the Editorial Board were always well received.

The Editorial Board of the Technical Bulletin would like to convey their deep sympathy to the bereaved family.



The effects of fumigants on garlic

by

Dr. MOORGESSENPILLAY RAMSAMY

Scientific Officer (Entomology)

SUMMARY

The technology for protecting garlic from arthropod pests under our tropical conditions needs to be developed in parallel with the production of a sufficient amount of this commodity to meet local demand. The key post harvest pest of garlic is Tyrophagus putrescentiae *Schrank, an astigmatid mite, which can be controlled under negative pressure by fumigation with either ethylene dibromide (EDB) or methyl bromide (MB) at the rate of 40 g/m³. EDB, however, caused a greater amount of garlic seed to become inviable than MB. Seed viability was found to decrease with exposure to the chemicals and with storage. When protected as bulbs in their tunica, seeds were less affected by the chemicals than when exposed as cloves.*

RÉSUMÉ

Afin d'accroître la production de l'ail à un taux qui permettait l'arrêt de toute importation, il est nécessaire de développer une technologie protectrice de cette denrée alimentaire contre les parasites, mites et autres arthropodes. Le parasite le plus important de l'ail est le mite astigmatique, Tyrophagus putrescentiae *Schrank, qui se prête au conrôle par des fumigènes tel que la dibromure éthylique et la bromure méthylique à la dose de 40 g/m³. Une perte plus considérable des semences est engendrée par l'utilisation du premier produit. La viabilité des graines diminue en proportion avec le temps de l'exposition avec les produits chimiques et l'emmagasinage. Quand les semences sont exposées aux produits chimiques avec leurs coques protectrices, elles sont moins affectées que lorsqu'elles sont éparpillées en gousses.*

INTRODUCTION

Mauritius consumes annually an average of 450 tons of garlic, of which 300 tons are imported (Anon 1983). It was therefore proposed to increase local production up to the level where all import of this commodity is stopped. Garlic, in Mauritius, is planted in March and harvested in August. The harvested crop must be stored for consumption throughout the year and for seeds for plantation in the next season. Storage facilities for such a quantity of garlic already exist at the Agricultural Marketing Board but the technology for long term storage in relation to control of erosion from arthropod pests under our tropical conditions deserves immediate attention.

The key post-harvest arthropod pests of garlic have been identified as: the astigmatid mite, *Tyrophagus putrescentiae* Schrank and the lepidopteron, *Ephestia cautella* Walker (Ramsamy 1983), the former is by far the most devastating.

Tyrophagus putrescentiae starts its attack directly in the field. The adult females lay their eggs scattered on the bulb. From the egg hatches a six legged larva which passes through two eight legged nymphal stages before metamorphosis into adult. Temperature and relative humidity greatly influence the length of the life cycle and the concomitant rate of increase. Under ideal conditions, which prevail in our barns and granaries *T. putrescentiae* can increase up to twelvefold in one week (Anon 1981). During 1983 and 1984, *T. putrescentiae* was particularly damaging to garlic but fortunately, through trial and error chemical protection was finally provided to garlic seeds destined for plantation by dusting with a mixture of one part by weight of peropal (azocyclotin) powder (a.i. 25%) and 4 parts by weight of malathion (carbophos) powder (a.i. 4%). Such control system, however, may not be applied to garlic for human consumption.

A more comprehensive solution for preserving seeds in general is to fumigate them with a suitable chemical such as methyl bromide (MB) or ethylene dibromide (EDB). Eggs of mites however, present some difficulties, being resistant to fumigants and the only way to get rid of them completely is to fumigate a second time, after the eggs have hatched (Anon 1981).

MB and EDB have both the proven desirable properties for disinfesting many grains and seeds from arthropod pest without impairing the food quality and taste to an unacceptable extent, but, their effect on viability of planting materials and other agronomic properties need to be investigated. The present paper deals with the germination of garlic treated with these two fumigants.

MATERIALS AND METHODS

A factorial experiment with four replicates in randomised blocks was designed. The factors investigated were:—

1. Fumigants: two chemicals, EDB and MB.
2. Exposure duration: No exposure (control), 1 hour, 2 hours and 3 hours
3. Garlic seeds: whole bulb and cloves
4. Storage: control (no storage), 1 month 2 months and 3 months.

The facilities for fumigation were made available at the Quarantine Section of the Plant Pathology Division, Fort George, Port Louis. The concentration of both EDB and MB used was 40 g/m^3. Higher dosages were found to be detrimental to several species of seeds (Ramsamy 1984). After exposure to the chemicals the garlic seeds were stored at the cold storage rooms of the Barkly Experimental Station at $12 \pm 3°c$ and RH 70%. The batches receiving no storage treatment were planted immediately after exposure to the chemicals. The garlic bulbs were shredded into cloves only before plantation time.

The seeds were planted in fibre glass trays (measuring $45 \times 30 \times 8$ cm) containing some 4 cms of sterilized soil. The trays were watered every two to three days with tap water. Germination counts were made 3 weeks after the date of seeding. Germimination counts were calculated into percentage, zero percent and 100 percent which occured in few trays were taken as 0.5 and 99.5 respectively. The percentage data were transformed into arcsine to stabilize variances before the final statistical analyses.

RESULTS AND DISCUSSION

Table 1 presents a summary of the analysis of variance of the percentage data transformed into arcsine.

The replicates or blocks showed no significant difference, but, all the main treatments and most of their interactions showed strong significance at low levels of probability.

Table 2 presents the means for the blocks and main treatments in arcsine and percentage. The standard deviation and LSD relate to the arcsine values. The percentage values on the right of the arcsine values have been calculated back from the arcsine data (and have been included for the sake of discussion).

The means between the blocks showed no great differences, showing that the materials worked with were fairly homogenous. Of the two tested chemicals EDB affected germination the lesser. Treatment with EDB caused a drop of 37.4% of germination as compared to treatment with the MB.

The exposure of garlic to the chemicals showed a decrease in germination even for the low time interval of one hour. After the first hour of exposure germination rate appeared to plateau and further additional exposure time brought little further depression in survival. The storage of treated garlic seeds had a drastic effect on survival. A decline in mean percentage germination occurred rapidly with an increase in storage intervals. Keeping treated seeds for a period of 3 months brought % germination down to 48.2%. After 3 months of storage a loss of 41.4% of seeds occurred. Treating garlic seeds in the bulb state, still within their tunica, had the effect of palliating the debilitating properties of the chemicals; when treated as bulbs a mean of 76.5% of the seeds survived whereas only 68.6% when treated as cloves.

Table 3 presents the interaction between chemical and storage treatments upon mean germination. Although both MB and EDB caused substantial regressions in seed survival with increasing storage periods, the latter chemical produced a more rapid and pronounced fall in germination rates. Even among seeds which were not stored, percentage germination was significantly higher within the MB treatments (94.8%) than within the EDB treatments (83.1%).

Table 4 summarises the interactive effects of exposure to the chemicals and storage on survival. A decline in viability of seeds was noted even when seeds were stored without having been exposed to the chemicals (control). A drop of 21.6% was thus observed among untreated seeds after 3 months of storage. When exposed to chemicals for one hour only, the effect of storage on the seeds became accentuated and a greater percentage loss occurred.

However any further subsequent increases in exposure after the first hour brought no additional significant mortality responses, within the tested exposure intervals. This observation was found to be true for all the tested storage periods.

The interaction between exposure intervals and chemicals is presented in Table 5. These results revealed MB to be, to all intent and purpose, a very mild chemical as far as germination is concerned. The effcet of EDB on the other hand, was shown to be very destructive, causing percentage germinations to drop from 91.6% (controls) to 50.1% for the very first hour of exposure. Longer exposition to EDB produced proportional increased fall in germination.

Tables 6, 7 and 8 depict the interaction between the tested states of garlic with storage, chemicals and exposure respectively. In most cases, bulbs showed higher survival rates over cloves.

CONCLUSIONS

There is little doubt that fumigants such as MB and EDB will control mites in garlic, but, if the fumigated materials is safe for human consumption, it is not suitable for plantation purposes. Seeds obtained after harvest in August will have to be stored for at least 6 months before the plantation date in March and when fumigated prior to storage very few seeds will survive the combined effect of the chemical treatment and storage.

MB produced less damage to seeds than EDB and is therefore recommended as the fumigant of choice for treating mite-infested garlic for human consumption. MB is also less toxic to man than EDB (Monro 1969). The latter is also known to affect seeds with high oil content such as soya bean, ground nut etc. (Plaut 1957) and as garlic is also a material rich in oil, EDB must not be used to fumigate it.

Fumigation has been found to have a negative impact on the viability of seeds and is clearly not the solution for disinfecting garlic destined for plantation. In the absence of an alternative treatment it is recommended that garlic seeds be dusted with 4 parts by weight of malathion powder and 1 part by weight of peropal powder (Ramsamy, 1984), until a more suitable solution is found.

ANALYSIS OF VARIANCE OF ARCSINE* TRANSFORMED% DATA

Strata & Effects	*Sum of Sqrs*	*D.F.*	*Mean Squares*	*F. ratio*	*P*
Blocks	363.4	3	121.1	1.47	0.22
Storage	34897.2	3	11632.4	141.14	<0.01
Chemical	49250.8	1	49250.8	597.60	<0.01
Exposure	18368.3	4	4592.1	55.72	<0.01
Garlic state	2026.3	1	2026.3	24.59	<0.01
Storage & Chemical	5872.7	3	1957.6	23.75	<0.01
Storage & Exposure	1734.6	12	144.5	1.75	0.06
Chemical & Exposure	13878.5	4	3469.6	42.10	<0.01
Storage & Garlic	2688.1	3	896.0	10.87	<0.01
Chemical & Garlic	3.7	1	3.7	0.05	0.81
Exposure & Garlic	1676.7	4	419.2	5.09	<0.01
Storage & Chemical & Exp.	2348.1	12	195.7	2.37	0.01
Storage & Chemical & Garlic	144.6	3	48.2	0.58	0.63
Storage & Exposure & Garlic	3070.8	12	255.9	3.10	<0.01
Chemical & Exp. & Garlic	567.3	4	141.8	1.72	0.15
Storage & Chemical & Exp. & Garlic ...	1163.1	12	96.9	1.18	0.30
Residual	19532.3	237	82.4	—	—
TOTAL ...	157586.7	319	—	—	—

*The arcsine transformation was utilised to stabilise variance before statistical finalysis.

TABLE 2

EFFECT OF MAIN TREATMENTS ON MEAN GERMINATION

Strata		0	%	0	%	0	%	0	%	0	%	*L.S.D. 1%*
		R1		R2		R3		R4				
Blocks	...	60.0	75.0	57.1	70.4	58.1	72.1	58.6	72.9			3.7
		MeBr		$EtBr_2$								
Chemicals	...	70.9	89.2	46.1	51.8							2.6
		0H		1H		2H		3H		4H		
Exposure	...	73.2	91.6	56.4	69.4	57.1	70.5	52.6	63.0	53.0	63.7	4.1
		0M		1M		2M		3M				
Storage	...	71.2	89.6	64.8	81.9	53.8	65.1	43.9	48.2			3.7
		Bulbs		Gloves								
State of Garlic	...	61.0	76.5	55.9	68.6							2.6

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0 =arcsine $\sqrt{\text{(Percentage Germination)}}$

% =Percentage

R1, R2, R3 and R4 =Replicates

MeBr =Methyhl bromide

$EtBr_2$ =Ethylene dibromide

H =Exposure time (in hours)

M =Storage intervals (in months)

L.S.D. =Least Significant Difference

TABLE 3

INTERATION BETWEEN CHEMICALS AND STORAGE PERIOD

	0–Month		*1–Month*		*2–Months*		*3–Months*	
Chemical	*0*	*%*	*0*	*%*	*0*	*%*	*0*	*%*
Methyl Bromide ...	76.7	94.8	76.9	94.9	69.8	88.1	59.9	74.9
Ethylene Dibromide ...	65.7	83.1	52.8	63.4	37.8	37.5	28.0	22.0

L.S.D. at 1% level: 5.2

0=Arcsine $\sqrt{(\%\text{Germination})}$

TABLE 4

INTERATION BETWEEN EXPOSURE DURATION AND STORAGE PERIOD

	0–Month		1–Month		2–Months		3–Months	
Storage	*0*	*%*	*0*	*%*	*0*	*%*	*0*	*%*
Exposure								
0 hour ...	... 81.2	98.0	77.0	94.9	72.9	91.4	60.9	76.4
1 hour ...	... 73.3	91.8	63.7	80.3	49.6	57.9	39.3	40.1
2 hours ...	... 67.7	85.6	66.1	83.6	52.8	63.4	41.9	44.6
3 hours ...	... 68.3	86.4	57.8	71.5	46.7	53.0	37.4	36.9
4 hours ...	... 65.0	82.2	59.6	74.3	47.0	53.5	40.2	41.7

L.S.D. at 1% Level=8.3

0=Arcsine $\sqrt{(\%\text{Germination})}$

TABLE 5

INTERATION BETWEEN EXPOSURE DURATION AND CHEMICALS

	Exposure									
	0 hour		*1 hour*		*2 hours*		*3 hours*		*4 hours*	
Chemical	*0*	*%*	*0*	*%*	*0*	*%*	*0*	*%*	*0*	*%*
Methyl Bromide ...	73.2	91.6	67.9	85.8	72.8	91.3	70.3	88.7	70.1	88.4
Ethylene Dibromide ...	73.2	91.6	45.0	50.1	41.4	43.8	34.8	32.5	35.8	34.3

L.S.D. at 1% level: 5.8,

0=Arcsine $\sqrt{(\%\text{Germination})}$

TABLE 6

INTERATION BETWEEN STORAGE AND STATE OF GARLIC PERIOD

	Storage period							
	0 Month		*1 Month*		*2 Months*		*3 Months*	
State of garlic	*0*	*%*	*0*	*%*	*0*	*%*	*0*	*%*
Cloves ...	... 68.4	86.4	63.9	80.7	54.5	66.3	36.9	36.1
Bulbs ...	... 74.1	92.5	65.1	83.1	53.1	63.9	51.0	60.4

L.S.D. at 1% level: 5.2,

0=Arcsine $\sqrt{(\%\text{Germination})}$

TABLE 7

INTERATION BETWEEN STATE OF GARLIC AND CHEMICALS

	CHEMICAL			
	Methyl	*bromide*	*Ethylene*	*dibromide*
State of garlic	**0**	*%*	**0**	*%*
Cloves	68.5	86.5	43.4	47.3
Bulbs	73.2	91.7	48.7	56.4

L.S.D. at 1% level: 3.7

TABLE 8

INTERATION BETWEEN STATE OF GARLIC AND EXPOSURE DURATION

	Exposure duration									
	0 hour		*1 hour*		*2 hours*		*3 hours*		*4 hours*	
State of garlic	*0*	%	*0*	%	*0*	%	*0*	%	*0*	%
Cloves ...	... 75.0	93.3	53.2	64.1	52.9	63.5	50.1	58.8	48.6	56.2
Bulbs ...	... 71.3	89.7	59.7	74.6	61.4	77.1	55.1	67.2	57.3	70.9

L.S.D. at 5% level: 5.8,

0 = Arcsine $\sqrt{(\%\text{Germination})}$

ACKNOWLEDGEMENTS

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(1) Mr. R. K. Ramnauth, Scientific Officer of the Agronomy Division for the statistical analyses.

(2) Messrs. C. Appasamy and D. Hulkua, Laboratory Attendant and Agricultural Assistant respectively of the Entomology Division for their dedicated assistance.

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Pest Control in Mauritius and Rodrigues

by

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INTRODUCTION

Mauritius has a small indigenous insect fauna and apart from very few exceptions, all pest species have been introduced. Early travellers into the country brought in many insects that infested homes, crops and animals. International commerce and better communications have accelerated such introductions. Long ago, few legal restrictions on the importation of plant and animal products were in effect, and, as a result many of the most important economic arthropod pests found in the country to-day are foreign in origin. With the strict regulatory measures presently in force in the country, the risk of entry of new pests and diseases, from foreign countries, are greatly minimized.

Pest control in Mauritius in the agricultural sector at least, is practised in a different way as compared to many countries with similar agricultural facet. Sugar cane and tea, the two crops covering large areas of land are fortunately not subjected to heavy and regular pest attacks which necessitate chemical control. In the case of sugar, natural enemies introduced by past entomologists are exercising good control over the array of pests found on this crop. Tea is also not under heavy attack from insect or mite pest.

Other food crops which are susceptible to regular pest attack rely heavily on chemical control to check their arthropod pest complexes.

It is relevant to note that soil insect fauna are not of considerable importance and therefore soil treatment is not practised on large scale and hence pollution through insecticide seepage is not widespread and important. Aerial application of pesticide is not a common feature in pest control and again does not contribute in increasing pollution.

The production of food crops is the business of both small and large farmers which include the Sugar Estate owners, the latter concentrating more on the cultivation of potatoes, maize, beans and peanuts, whereas the former grow a large variety of crops. Flower production, mainly, anthurium is grown on a commercial scale by individual farmers big and small as well as Sugar Estates and Agricultural Companies. The bulk of food crops harbours a complex of insect and mite pests, which need to be checked if a clean, high yielding crop is to be expected.

Pesticide use has played a significant role in the intensification of agricultural production in Mauritius, especially after the advent of the modern post World War II synthetic pesticides and it can be anticipated that the ever increasing demand for food will necessitate a greater reliance on pesticides.

Over the last two decades, Mauritius has experienced a substantial increase in the consumption of certain pesticides for agricultural use particularly with respect to the organophosphates, carbamates and the synthetic pyrethroids. Other groups such as some organochlorines as a rule have witnessed a market contraction due to restrictions in their use.

Pest problems have intensified in Mauritius because of the introduction of new pests; others have become more difficult to control. Finally new problems have arisen from the appearances of resistant strains of pests, or from the emergence of new pests due to the disruption of biological equilibria.

PESTICIDES AND APPLICATION MACHINERY USED IN PEST CONTROL

PESTICIDES

Pesticides are substances used to kill, destroy, repel or prevent a pest. Pests are controlled by a wide variety of chemicals. In Mauritius the following group of pesticides is in current use.

Insecticide	:	to destroy insect
Acaricide	:	to kill mites
Fungicide	:	to destroy fungi
Herbicide	:	to control weeds and other undesirable plants
Nematicide	:	to kill nematodes
Molluscicide	:	to destroy snails and slugs
Rodenticide	:	to kill rodents particularly rats

Pesticides are classified in various ways. A common method is to group them according to their type of action, for example, stomach poison, contact poison, fumigants, repellents, attractants and chemosterilants. Stomach and contact poisons are commonly used in Mauritius for the control of agricultural pests. Most of these chemicals are applied as foliar sprays. Fumigants are adapted to use in enclosed spaces like granaries, stores, ships and airplanes.

Fumigants are less frequently used in agriculture. They are used mostly for temporary control of mosquitoes, flies, stored pests, in buildings and in certain outdoor areas. Outdoor applications are usually made in the afternoon when temperature and wind condition are most favourable. This method of control has been successfully used against the biting flies *Stomoxys nigra* and *Stomoxys calcitrans* in large open spaces where deer are raised. This type of control measure is preferred, as direct sprays on animals or residual sprays on hard surfaces are simply not possible.

Chemosterilants have not been used in commercial pest control due to their carcenogenous nature.

FORMULATION OF PESTICIDES

Formulation of a pesticide is the mixing of an active ingredient with a carrier or diluent, either liquid or solid. This is done to make pesticides suitable for application or in some cases attractive to a pest (e.g. bait). They are applied as sprays or dusts or sometimes in granular form. In a few cases pesticides are soluble in water, but in general, if they are to be used as sprays, they are available either as emulsion or wettable powders, and used appropriately diluted with water. In Mauritius, pesticides are available in various formulations: these are aerosols, baits, dusts, emulsifiable concentrate, flowables. fumigants, granules, soluble powders, solutions and wetable powders. On local agricultural crops, mostly emulsifiable concentrates and wettable powders are used as foliar sprays. Baits are sometimes used to control soil inhabiting pests. Granules are not commonly used, but some are very effective ex. Furadan has been reported to be very effective in controlling some potato and rice pests. Dry pesticides are generally used as dusts and in Mauritius they are used for top dressing or in the control of stored pests. Only very rarely are undiluted active ingredients used to control field pests in Mauritius.

APPLICATION MACHINERY

Numerous types of equipment are in use in Mauritius for the application of pesticides. They range from small hand-operated outfits to power sprayers capable of treating large acreage. Four classes of power spraying and dusting equipment are in use for pesticide application, they are (1) Hydraulic sprayers (2) Air sprayers (3) Fog applicators (4) Dusters.

The two types commonly used are the hydraulic and the motorized sprayers. Fog applicators and dusters are mainly used by Government bodies or specialized agencies involved in pest control. Hydraulic sprayers are the most commonly used by farmers for the application of insecticide, fungicide and herbicide. Motorized sprayers probably due to their prohibiting costs, are mostly employed in pest control by big farmers, sugar estates and Government pest control units.

Tractor mounted sprayers either hydraulic or motorized are generally not in use in the island.

PEST CONTROL METHODS

Chemical control

From the beginning two main approaches to pest control are discernible in Mauritius, chemical control and biological control; though hand picking, cultural control, physical control have from time to time been attempted as control measures for checking insect pest population. For example, in the 1930's hand picking of larvae and adults supplemented with recommended cultural practices and resistant varieties were among the control measures adopted for bringing dowwn the population of the notorious sugar cane pest *Clemora smithi*.

The beginning of chemical pest control started as early as 1932 when Cyanogas was tried against *Clemora smithi*. This was followed in later years (1946-50) by the use of both inorganic and organic insecticides such as arsenicals, sulphur, botanicals such as nicotine, derris and pyrethrum; petroleum oil and dinitrophenols against several pests including *Clemora smithi*, red locust *Nomadacris septemfasciata* and *Aspidiotus destructor*. Despite the apparent effectiveness of some of these compounds, particularly the arsenicals, they did not frequently provide satisfactory control in a number of areas where they were recommended. Furthermore some of these compounds caused chronic injuries to plants. Thus with inadequate control and plant injury, entomologists were receptive to new insecticides.

Then came the discovery of DDT in 1939. The emergence of this miracle product and a few of the chlorinated hydrocarbons such as Aldrin, Dieldrin on the market, had a major impact upon the control of both agricultural pests and pests of medical importance in the world. With spectacular successes at a relatively low cost, these synthetic organic insecticides rapidly became a primary tool of pest control in productive agricultural regions and they did not take long to gain access in tropical countries including Mauritius. In the late 1950, most of these compounds had already reached our market and though Mauritius has been in the front line in the field of bioligical control, whereby natural enemies were exercising control on an important category of pests, the Mauritian farmers did not hesitate to use these newly discovered compounds against an array of pests found on foodcrops.

In terms of quantity, agriculture accounts for the single largest use of pesticide in Mauritius, crops accounting for over 95% of the amount used. Use varies considerably among crops, the determining factors being (1) pests to be controlled and their distribution (2) severity of attack (3) climate (4) value of the crops (5) availability of alternative methods (6) human attitudes.

No data are available upon the pesticide use in non-agricultural sector, however the malaria eradication campaign has consumed a substantial portion of insecticide, especially DTT, for the killing of adult anopheline mosquitoes. Larval stages, having been decimated by the elimination of stagnant waters, did not require application of insecticide for their control. Example of other non agricultural uses include household pest control, control of termites and other pests affecting non-residential buildings like industrial complexes.

LIMITATION TO PESTICIDES

Despite the enormous gains realized from using chemical pesticides, limitations are becoming increasingly apparent and this is a world-wide phenomenon, Mauritius though to a lesser extent cannot escape it.

For more than three decades, the persistent organochlorinated compounds have provided highly efficient insect vector and plant pest control, but concern about environmental implications has for the last 15 to 20 years led to considerable reduction in their use by local farmers.

In Mauritius, very few pesticide monitoring surveys have been conducted, but results from different countries confirm the residue trends in various areas where such compounds have been used. Examples of residues, above acceptable limits of DDT abound. Apart from environmental implications, three dangers exist resulting from the heavy reliance on these chemicals, namely pest resistance, pest resurgence and pesticide residues. Such cases are not rare in Mauritius. Apart from the effects of long term low-level dosages of chemical pesticide on public health, direct human poisoning from accidental or deliberate intoxication is causing alarm.

Table 1 shows the most commonly used insecticides and acaricides on agricultural crops together with their mode of action, toxicity and dosage used per hectare.

TABLE 1

Commonly used insecticides	*Mode of action*	*Dosage Ha*	*Insects controlled*	*Toxicity*	*Safety interval (days)*
1. Azodrin 55% WSC ...	SY.	½L	Foliage feeders & sap suckers	Highly toxic	21
2. Basudin 60% EC ...	C., St., F.	¾L	Foliage feeders and soil pests	Moderately toxic	21
3. Basudin 10% G ...	C., St.	15–20 kg	Foliage feeders, soil pests	M.T.	21
4. Baythroid 0.50 SL (5%)	C., St.	¼L	Biting pests	M.T.	2
5. Cymbush 10% EC ...	C., St.	¼L	Biting pests	M.T.	2
6. Decis 2.5% EC ...	C., St.	¼L	Biting pests	M.T.	2
7. Dimecron 50% EC ...	SY	¼L	Sap suckers	H.T.	10
8. Folimat 50% WSC ...	SY	½–¾L	Sap suckers	H.T.	21
9. Furadan 10% G ...	SY	10–25 kg	Sucking insects	H.T.	60
10. Gusathion 20% EC	C., St.	¾–1 L	Foliage feeders	H.T.	14
11. Lannate 25% W.P ..	C., St., SY	1 kg	Foliage feeders & sucking pests	H.T.	7
12. Lannate 90% SP ...	C., St., SY	250 g	Foliage feeders & sucking insects	H.T. M.T.	7
13. Karate ...	C.	½ L	Foliage feeders	M.T.	2
14. Meta Bait granular 5%	St.		Snails	Low toxicity	
15. Mesurol ...	C., St.	½ L	Foliage feeders	M.T.	7 to 14
16. Mitac 20% EC ...	C.	1 L	Mites	L.T.	7
17. Morestan 25% W.P.	C.	½ kg	Mites	L.T.	14
18. Morocide 50% W.P.	C.	¾ kg	Mites	M.T.	14
19. Nogos 50% E.C. ...	C., St., F.	¾ kg	Ants	H.T.	2
20. Nuvacron 50% E.C.	SY., C.	½ L	Sap suckers	H.T.	21
21. Peropal 25% WP ...	C.	½ kg	Mites	M.T.	14
22. Tamaron 60% WSC	SY., C.	½–¾ L	Sap feeders	H.T.	21
23. Volaton 0.5% ...	C., St.	6–12 kg	Soil insects	L.T.	—

C ..... contact poison

St. ..... stomach poison

SY ..... systemic poison

F ..... Fumigant action

Insecticides are normally applied as sprays prepared from emulsions, wettable powders or solutions. It is useful to remember that it is the quantity of actual pesticide per hectare which is important in effective control, its dilution is not of great importance except in cases where insecticide, if too concentrated may be phytotoxic.

With regard to quantities of pesticide to be used, the general recommendation would depend upon (1) the crop (2) stages of growth at which the crop is affected, (3) Nature of the formulation, (4) insect species and stages of development, (5) weather conditions.

BIOLOGICAL CONTROL

Biological control consists of using parasites, predators and pathogens for the reduction of pest population.

Mauritius has been in the front line in the field of biological control in this region of the world. Mauritius has the distinction of probably being the first country in the world to have attempted this mode of control by the introduction of the Indian Minah in 1762 to fight the red locust. Biological control has been in the past and still is the most sustained alternative control method used in Mauritius. It has been a major tool for keeping many important sugar cane as well as other crop and veterinary pests under tolerable level. Its successful utilization in the past has been due to the continuous and dedicated efforts of our past entomologists like D'Emmerez de Charmoy, André Moutia, A. Mamet and Jepson, Dr. A. Orian and J. Monty, all careers officers in the Department of Agriculture. Biological control though started as early as 1700, was systematically tackled with the appointment in 1913 of D. D'Emmerez de Charmoy for the control of *Clemora smithi.* Several missions proceeded abroad to search for parasites between 1932 to 1939. Countries visited included Madagascar, Puerto Rico, Phillipines, Java, Malaya, South Africa, East Africa, England and France. From 1940 onwards the problem of *Clemora smithi* became less severe due to factors other than natural insect enemies.

Other major pests in sugar cane were the borers, *Sesamia calamistis, Chilo saccariphagus.* These pests are kept under control due to various introductions of natural enemies made in the past. In 1957, the Mauritius Sugar Industry Research Institute (MSIRI) was constituted and sugar cane research including entomology became the major activity of that institution. From its creation to date, researchers of both the Ministry of Agriculture and MSIRI have been working in close collaboration in the field of biological control and no effort is being spared to develop biological means for the control of agricultural pests.

Successful cases of biological control are many, but it cannot be expected to work in all pest situations. However the economic return relative to pesticide use can be substantial, whenever it is effective.

MICROBIAL CONTROL

Microbial control is part of general biological arthropod control whereby disease producing microorganisms rather than parasites and predators are utilised in the control of pests.

The most spectacular example of microbial control in Mauritius perhaps relates to the significant control of *Oryctes rhinoceros,* the coconut beetle. After its appearance in the North-West coast of Mauritius in 1961-62, biological control using parasites and predators was actively undertaken. Despite great efforts to use natural enemies this method did not seem to have had any appreciable effect on the pest. Sanitary and chemical control undertaken during the same period contributed very little to check its population.

In 1971, the virus *Rhabdionvirus oryctes* was introduced by the former entomologist Mr. J. Monty. Within two years after its liberation into the pest's inhabiting environment, a spectacular drop in the beetle's larval and adult population was noticed. Damage of coconut dropped from 100% to 10% and up to now the population of this pest is kept under good control by this pathogen.

INTEGRATED PEST CONTROL

This is the utilization of all suitable techniques to reduce and maintain pest population at levels below those causing injury of economic importance to Agriculture and Forestry and at the same time keeping adverse side effects to their minimum. The system must on rest on firm ecological principles and approaches.

Efforts have been underway to integrate control methods into a pest management system. Integrating mechanical, chemical and biological control methods was attempted between the year 1911 to 1938 to control one of the most important pest of sugar cane of this period *Clemora smithi.*

A field where reasonable control has been achieved more recently is exemplified by the control of the two biting flies *Stomoxys nigra* and *Stomoxys calcitrans.* Here several methods have been integrated to bring down the population of these two pests to tolerable levels.

The use of traps (mechanical control) in cow byres has greatly reduced the discomfort caused to animals by adult flies which gain access to these byres. The adult population is further reduced chemically by residual sprays, on hard surfaces and/or by direct sprays on animals.

Percentage parasitism of larvae and pupae reaching up to 70% has been obtained by combined action of the encyrtid parasite *Tachinaephagus stomoxicida, Trichopria* sp. of the Diapriidae family.

Biological control of both larvae and pupae also plays an important role in keeping down the flies population.

REGULATORY CONTROL

The fundamental principle of this mode of control consists mainly in preventing the entry and establishmtnt of foreign plant and animal pests in the country.

The accelerated movement of plants and plant products throughout the world has increased the opportunity for arthropod pests to move from one country to another. Facilitation of international trade in recent times has increased this threat. Safeguards are therefore essential in preventing the introduction of dangerous pests which present hazards to agriculture. The objectives of regulatory control is to minimize this risk. The best and most economical safeguard is through an adequate plant quarantine. To make this procedure effective, the Plants Act was promulgated in 1976. This Act gives the Ministry of Agriculture definite responsibilities in carrying out preventive control measures of which quarantine is a major component.

Another aspect of regulatory control pertains to pesticide regulation. The Pesticide Control Act of 1970 which is administered by the Ministry of Health aims at regulating the import, sale, manufacture and use of all pesticides.

CONTROL OF COMMON PESTS

INTRODUCTION

Pests associated with plants are numerous and can be very destructive. There are a few serious soil insects that attack crops. There are also those that attack the foliage and stems creating a great deal of damage.

Pests that attack flowers, fruits and seeds are perhaps the most important and since damage at this stage comes at a time when the grower has put a maximum input, losses are consequently much higher.

Although chemical control occupies an important place in the production of clean crops, there are many aspects of good husbandry which will help the farmers to check the incidence of a pest both at field and post harvest level.

The most important of these methods is clean cultivation particularly the elimination of weeds, specially those botanically related to the crop plants. Crop remnants and fallen fruits are just as important as weeds, if not disposed of, they provide a breeding ground for pest multiplication.

Despite all the precautions a farmer may take, there will be occasions when circumstances quite beyond his control will give rise to pest outbreaks, which can only be dealt with, through the use of pesticides. Pesticides also have their value in prevention where it is known that an area is subject to attack by a particular pest.

Below is a brief account of the economic importance and control measure of the most severe pests affecting both field crops and livestock.

SOLANACEOUS CROPS

Among the vegetables, the two solanaceous crops, tomatoes and potatoes receive the largest chemical treatments. Regular chemical control is necessary to check the American serpentine leaf miner *Liriomyza trifolii, Thrips palmi,* a newly introduced pest attacking a variety of vegetable crops and the fruit boring caterpillar *Heliothis armigera.* The red spider mite, *Tetranychus* spp. also forms part of the pest complex of tomatoes and needs control. The control programme for these crops ranges from 12 to 15 chemical treatments.

Egg plant, another member of the solanaceous group, is intensely attacked by *Thrips palmi.* A few insecticides like Mesurol, Selecron, Marshal have been tested and found to be very effective in controlling this pest.

CRUCIFEROUS CROPS

The Brassica crops (cabbage, cauliflower, chinese cabbage) is grown in winter and partly in summer as some summer varieties of cabbage are now available. Throughout the tropics, Brassica are attacked by a similar complex of pests, all the most important being lepidoptera. Of these, *Plutella xylostella* is the most important. Recently this pest has been under heavy insecticidal pressure without much harm. If left untreated, Brassica crops can be rendered totally unmarketable by insect attacks. Other less important lepidopterous pests are *Crocidolomia binotalis* and *Hellula undalis.* The newly tested synthetic pyrethoid Karate gives appreciable control of *P. xylostella.*

The Aphid *Lipaphis brassica* ranks among the sap suckers which can reach alarming proportion if not checked by systemic insecticide like Dimecron.

CUCURBITACEOUS CROPS

This group comprising of cucumber, water melon, squash and others is subjected to attacks by several pests. The most important ones are the melonfly *Dacus cucurbitae,* the serpentine leaf-miner *Liriomyza trifolii* and *Thrips palmi.* Synthetic pyrethoids are utilized for the control of *Dacus cucurbitae.*

LEGUMINOUS CROPS

Pests of legumes are mainly the pod borers belonging to the lepidoptera. These pests, namely *Maruca testulalis, Lampides boeticus, Etiella zinckenella,* bore into pods of legumes and thus render them unconsumable. The bean fly, *Melanoagromyza phaseoli* though recorded as an important pest is being controlled at the onset of attack. However, *Thrips palmi* and *Liriomyza trifolii* both polyphagous in nature can cause great losses to these crops of proper control measures are taken (see Table 2).

ONION AND GARLIC

Pests which are injurious to onion and garlic are few but very destructive. They are the onion thrips, *Thrips tabaci* and to species of mites nemely *Tyrophagus putrescentiae* and *Aceria tulipae* which attack mostly garlic. Pesticides used in the control program include Mesurol and Peropal.

PESTS OF FRUITS

The pest problems in fruit are rather different and slightly more difficult to deal with as compared to field crops. This is because orchards and backyard gardens provide ideal situation for the rapid multiplication of insect pests. In orchard, host plants are available all the year and as such provide food continuously for certain pests.

FRUIT FLIES

Fruit flies are considered as the most damaging group of insect pests occuring on our fruits. The economic species are the Natal fruit-fly *Pterandrus rosa* and the Mediterranean-fly *Ceratitis capitata.*

The Mediterranean-fly, cosmopolitan in distribution, has lost some of its importance through displacement by the Natal fruit fly. The latter originated from Southern Africa, is the most damaging fruit-fly in Mauritius, the preferred host being peaches, guava, loquat, mango and bullock's heart.

CONTROL

At present only chemical control can claim to be the most effective. Regular sprayings with both systemic and contact insecticides have proved to be very successful.

PESTS OF CITRUS

Citrus insects and mites are important limiting factors in citrus production and therefore demand much attention from growers. Because pests are harmful to trees and fruits, pest control measures are essential to the growing of healthy trees and sound fruits.

CITRUS APHIDS

Both the citrus aphids *Toxoptera aurantii* and *Toxoptera citricidus* are of great significant importance to citrus. They are both sapsuckers and their association in large numbers with young vegetative parts can arrest growth, and may eventually induce leaf or bud drop. *Toxoptera aurantii,* apart from causing damage resulting from feeding, acts as a vector to phytopathogenic virus—disease, Tristeza and therefore its control is of primary importance.

CITRUS SCALE

The citrus red-scale *Aonidiella aurantii* is also an important pest of citrus. It is found on a wide range of other plants especially roses. The damage done by this pest is due to the combined effects of the removal of sap from the plant, the toxicological action of the secretions of the insect while feeding and the interference with the functions of the plant as a result of scale encrustation. Damage may be severe if left unattended. Control can be achieved by using systemic insecticides like Dimecron, Folimat.

THE WHITE FLIES

The white fly *Aleurothrixus floccosus* first recorded in March 1982, causes damage to citrus. Its parasite *Cales noacki* was introduced and released from Reunion Island in August of the same year. At present the population of *Aleurothrixus floccosus* has dropped down significantly, and it can be concluded that the parasite is exercising control on its host.

The citrus white fly *Dialeurolonga simplex* attacks particularly leaves and produce honey dew. This pest is easily controlled with systemic insecticides.

CITRUS PSYLLIDS

Trioza erytreae and *Diaphorina citri* are the two psyllids which affcet citrus. They are not only sapsuckers but also act as vectors of the greening disease of citrus. Nymphs of both species produce galls on leaves.

In 1985 and 1986, the natural enemies *Tetrastichus dryi* and*Tetrastichus radiatus* have been introduced from Reunion island to control these pests. It seems that the population of *Trioza erytreae,* the African psyllid as it is commonly known, is very much on the decline. This is possibly largely due to the effectiveness of the introduced parasite *Tetrastichus dryi.* The other species of psyllid is still predominant and it appears that though its paraiste *Tetrastichus radiatus* is causing a moderately high degree of parasitism in the field, the population of its host is not dropping significantly.

FLOWER EATING CATERPILLARS

The flower eating caterpillars *Prays citri* and *Chloroclystis* are occasoinal pests of citrus flowers, their control are not difficult. Lannate, Azodrin, synthetic pyrethroid are effective chemicals in their control.

CITRUS MITE

The citrus mite *Phyllocoptruta oleivora* is a major pest of citrus as it affect sbetween 70 to 100% of the fruits. Leaves and twigs may also be severely affected. Mites pierce and damage epidermial cells of fruits and other parts turning them rust like. Fruit surfaces become russetted, rough and scaly and thus lose their market value.

Acaricide is of common usage for its control. Due to their rapid development, spraying should be started as soon as the pest appears.

MISCELLANEOUS PESTS

These include insects which are not specific and attack a variety of crops.

CUTWORMS

Cutworms belong to the lepidopterus group. Their larvae inhabit below the soil level and come to cut off low growing plants. Species that feed above ground on part of plants were usually called climbing cutworms. Common cutworms which are most injurious to garden vegetables, tobacco, tomato, egg plant, are *Spodoptera litura, Spodoptera mauritia* and *Plusia orichalcea.* The last one belongs to the climbing cutworm group.

Cratopus sp. has been recorded on a variety of crops including tea, vine, rose plants, litchis and many ornamental plants. They are foliage feeders and these weevils do not reach alarming proportion in general and are easily controlled by various insecticides like Azodrin.

PESTS OF STORED PRODUCTS

Stored agricultural products like rice, flour, potatoes, garlic, bean, tobacco are threatened with infestation and destruction from several pest species. The stored product pests that attack grains include a few mite species.

Recorded species of stored products pests are:

Bean

Acanthoscellides obtectus a bruchid beetle

Rice

Sitophilus spp. (weevil)
Oryzaephillus surinamensis (grain beetle)
Tenebrio mauritanicus (beetle)
Ephestia cautella (flour moth)

Flour

Ephestia cautella (flour moth)

Garlic

Ephestia cautella (flour moth)
Aceria tulipae (mite)
Tyrophagus putrescentiae

Onion

Ephestia cautella (flour moth
Opagon sacchari (moth)

Potato

Ptorimaea operculella (tuber moth)

Tobacco

Lasioderma serricorne (tobacco beetle)

Some of these pests are brought into warehouses with each fresh crop. Others may live continuously in cracks, crevices or in remains of previously stored commodities and re-infest the new products brought in for storage.

CONTROL

Effective protection is essential during storage. If however imported produce is infested on arrival, it is normally fumigated. Other treatments are outlined below:—

TREATMENT OF STORE ROOMS

When store rooms become empty, they are cleaned thoroughly and then sprayed with a residual insecticide. This is followed by a thermal fogging using a mixture of Lindane/Pyrethrum.

TREATMENT OF BAGS

Filled bags are sprayed with malathion wettable powder.

TREATMENT OF GRAIN

Sometimes direct treatment of grain is effected by phosphine using special tablets. In such cases, the places to be fumigated must be completely sealed.

TREATMENT OF TOBACCO

Tobacco bales are effectively treated with methyl bromide under partial vacuum.

HOUSEHOLD PESTS

By maintaining dwellings in good order, pests can be to a large extent, excluded from houses. If they do get access, good hygiene prevents them from proliferating. Proper disposal of garbage solves also many problems.

In Mauritius, it is not possible everywhere for these basic requirements of general hygiene to be met and wherever this is the case, pests can be of domestic importance and sometimes can be a source of health problem.

In Mauritius, mosquitoes, flies, mainly houseflies, cockroaches, bedbugs, assasin bug, fleas, lice, ants, wasps, milipedes are among the major pests inhabiting human dwellings and their suppression is often necessary to keep a certain degree of clealiness in the house.

CONTROL

Generally both insecticides that have knock-down and residual effects are used in the house, control depends upon the pest problem.

For indoor pests small devices are used. Aerosols being readily available are effective in the control of flying insects like mosquitoes and flies. Normally the active ingredient contained in aerosols is a knock down insecticide.

For indoor crawlers, like cockroaches, bugs, fleas, lice, ants treatment consists mainly by the spray application of a residual insecticide. The residual sprays are usually applied by a small hand sprayer using formulations like emulsifiable concentrate or wettable powders. The sprays are usually directed to surfaces where these pests congregate, crawl or hide.

Dusting is sometimes used particularly for the control of bed bug and fleas.

RODENT CONTROL

Rats live in small groups in field burrows, nests and houses. They are active at night in search of food. The most important species being the brown rat *Rattus norvegicus* and the black rat *Rattus rattus*. Both species inhabit houses as well as fields. They are encountered in places where food is stored. In agricultural areas, they occur mainly where such crops as sugar cane, maize are grown. Rats can be a menace to poultry. Economic losses are mainly related to crop yields and stocks of agricultural produce.

CONTROL

Rats are best controlled by putting down poisoned baits at places where they live, roam and look for food. In fields, baits are laid at 10 to 15 places per hectare, according to infestation level.

PEST CONTROL IN RODRIGUES

Rodrigues has a different land relief (mostly hilly) from Mauritius. Recurrent droughts do not make it suitable for intensive agriculture. The main crops are maize, bean and onion. Livestock production is also a major activity.

Many of the agricultural pests recorded in Mauritius exist in Rodrigues.

PESTS OF VEGETABLES

TOMATOES AND POTATOES

Both these solanaceous crops are subjected to heavy attacks if not protected. Recently the notorious *Thrips palmi* was recorded on potatoes.

The fruit-fly *Pardalaspis cyanescens*, the fruit boring caterpillar, *Heliothis armigera*, the red spider mite *Tetranychus evansi* are all pests which affect tomatoes and are being chemically controlled.

BEANS

The pod borers *Maruca testulalis, Lampides boeticus* are of significant importance on bean. These can be chemically controlled using the synthetic pyrethroid groups—See Table 2 at the end.

ONIONS

The main insect problem is *Thrips tabaci*. Control has already been mentioned above under Onions and Garlic.

MAIZE

This important crop is subjected to heavy attack by the corn ear worm *Heliothis armigera*. Up to 75% of this crop can be damaged if control measures are not timely applied. Refer to Table 2 for control measures.

PESTS OF CITRUS

The black citrus aphid *Toxoptera aurantii* is a common pest occuring on citrus. As mentioned earlier, it causes damage by feeding on sap. It is also a vector of Tristeza.

The citrus psyllid *Trioza erytreae* is also a serious pest of citrus. It causes deformation of leaves a,nd acts as a vector of greening.

LIVESTOCK PESTS

The blue tick *Boophilus decoloratus* is predominant on cattle. Stable flies, though present on the island, does not represent a serous problem.

PESTICIDE USAGE

Pesticides are not widely used as in Mauritius. Pesticide application is mainly carried out by officers of Ministry of Agriculture and Minstry of Rodrigues.

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TABLE 2

RECOMMENDATIONS FOR THE CONTROL OF CROP PESTS

Crop	*Pest*	*Insecticides recommended*	*Dosage actual insecticides per ha*	*Safety interval (in days)*
1. Bean and other legumes ...	*(a) Liriomyza trifolii* ...	Trigard 75% WP	0.25 kg	14
	(b) Thrips palmi ...	Mesurol 75% WP, Dicarzol 50%	0.5 kg	14
	(c) Melanoagromyza phasecli	Tamaron 60% WSC or Azodrin 55% WSC	0.5 L	21
	(d) Tetranychus macfarlanei ...	Peropal 25% WP	0.5 kg	14
	(e) Maruca testulalis ...	Decis 2.5 EC, Cymbush 10 EC ...	0.25 L	2
	(f) Lampides boeticus ...	Baythroid 0.50 SL or Karaté		
	(g) Nacoleia praeteritalis ...	Lannate 25% WP	1 kg	7
2. Cabbage and other crucifers	*(a) Plutella xylostella*	Mesurol WP or	0.25 kg	14
	(b) Crocidolomia binotalis ...	Karaté	0.5 L	7
	(c) Agrotis ipsilon ...	Volaton 0.5%	12 kg	—
	(d) Spodoptera spp. ...	Decis 2.5 EC, Baythroid 0.50 SL or Cymbush 10 EC	0.25 L	2
3. Chillies	*(a)* The Mediterranean fruitfly *Ceratitis capitata*	Lebaycid 50% EC	1 L	7
	(b) Polyphagotarsonemus latus	Peropal 25% WP	0.5 kg	14
4. Egg plant	*(a) Thrips palmi* ...	Mesurol 75% WP or Dicarzol ...	0.25 kg	14
	(b) Tetranychus evansi ...	Peropal 25% WP	0.5 kg	14
	(c) Polyphagotarsonemus latus	Peropal 25% WP	0.5 kg	14
	(d) Icerya sp. ...	Folimat 50% WSC	0.5 L	21
5. Ginger	*(a)* Aspidiella zinziberi ...	Dipterex 80% (for rhizome treatment)	3 g. litre	—
6. Lady's finger	*(a) Earias insulana* ...	Lannate 90%	0.25 kg	7
	(b) Heliothis armigera			
7. Maize	*(a) Heliothis armigera* ...	Gusathion 20%	0.75 L	14
	(b) Sesamia calamistis ...	Volaton 0.5% or Basudin 10 G ...	6 kg & 15 kg resp.	—
	(c) Angustalius malacellus ...	Furadan 10 G	14 kg	—
8. Onion and Garlic ...	*(a) Thrips tabaci* ...	Mesurol 75% WP	0.25 kg	14
	(b) Aceria tulipae ...	Peropal 25% WP	0.5 kg	14
	(c) Liriomyza trifolii ...	Trigard 25% WP	0.25 kg	14
9. Pea	*(a) Nacoleia praetoritalis* ...	Lannate 90%	0.25 kg	7
	(b) Heliothis armigera } ...	Lannate 90%	0.25 kg	7
	(c) Maruca testulalis } ...	or		
	(d) Etiella zinckenella } ...	Decis, Cymbush or Baythroid ...	0.25 L	2
	(e) Liriomyza trifolii ...	Trigard 25% WP	0.25 kg	14
10. Potato	*(a) Liriomyza trifolii* ...	Trigard 25% WP	0.25 kg	35
	(b) Spodoptera litura ...	Tamaron 60%	0.5 L	21
	(c) Agrotis ipsilon ...	Volaton 0.5%	6 kg	21
	(d) Mocrosiphum euphorbiae ...	Tamaron 60%	0.75 L	21
	(e) Gnorimoschema operculella	Lannate 90%	0.25 kg	7
	(f) Polyphagotarsonemus latus	Peropal 25% WP	0.5 kg	14
11. Squash and other cucurbits ...	*(a) Dacus cucurbitae* ...	Decis, Cymbush or Baythroid ...	0.25 L	2
	(b) Aphis gossypii ...	Dimecron 50% or	0.25 L	14
	(c)	Folimat	0.5 L	
12. Tobacco	*(a) Heliothis armigera* ...	Lannate 90%	0.25 kg	7
	(b) Agrotis ipsilon ...	Volaton 0.5%	6 kg	—
	(c) Gnorimoschema operculella	Lannate 90% or Dimecron 50% EC	0.25 kg & 0.5 L	7
13. Tomato	*(a) Liriomyza trifolii* ...	Trigard 25% WP or Tamaron 60 %	0.25 kg or 0.5 L resp.	21
	(b) Heliothis armigera ...	Cymbush 10 EC	0.25 L	2
	(c) Pardalaspis cyanescens ...	Decis, Cymbush or Baythroid ...	0.25 L	2
	(d) Tetranychus evansi ...	Peropal 25% WP	0.5 kg	14
14. Watercress	*(a) Lipaphis erysimi* ...	Dimecron	0.25 L	14
	(b) Plutella xylostella ...	Decis, Karate	0.25 L & 0.5 L resp.	2 & 7 resp
	(c) Polyphagotarsonemus ...	Peropal 25% WP	0.5 kg	14

TABLE 3

Fruit trees	*Pest*	*Insecticides recommended*	*Dosage actual insecticides per ha*	*Safety interval*
1. Jujube	(1) *Pterandrus rosa* ... ... (2) *Carpomyia vesuviana*	Decis, Cymbus 10% EC ...	0.25 L	2
2. Custard apple ...	(1) *Anonapestis bengalella*	Folimat 50%	0.5 L	21
3. Citrus	(1) *Aleurothrixus floccosus* ... ... (2) *Toxoptera aurantii*	Folimat 50%	0.5 L	21
	(3) *Toxoptera citricidus* (4) *Diaphorina citri*—vectors of greening	Folimat 50%	0.5 L	21
	(5) *Trioza erytreae* diseases (6) *Polyphagotarsonemus latus* ... (7) *Tetranychus cinnabarinus*	Peropal 25% WP	0.5 kg	14
	(8) *Phyllocoptruta oleivora*			
4. Guava, Peach, loquat, Bullock's Heart	(1) *Pterandrus rosa* ... ... (2) *Ceratitis capitata*	Decis, Cymbush and Baythroid ...	0.25 L	2

Appraisal and Evaluation of Agricultural Development Projects

by

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INTRODUCTION

The Land Use and Projects Division of the Ministry of Agriculture, Fisheries and Natural Resources is the main body concerned with the analysis of projects. This Division is responsible for recommending the issue of Agricultural Development Certificates (A.D.C.) to members of the public after carrying out technical, financial and economic feasibility studies of their porjects.

Since 1982, over 60 Agricultural Development Certificates have been issued to crop and livestock producers. The commodities produced, the target and actual productions are listed in Appendix I. According to the White Paper on Agricultural Diversification (1983) the holders of these certificates benefit from the following incentives:

(i) Exemption from the payment of Income Tax on dividends for a period of 10 years starting from the Production Day.

(ii) Customs Duty concessions on materials and agricultural equipment.

(iii) Availability of short or long term loans at preferential rates from the Development Bank of Mauritius.

(iv) Guaranteed prices from Agricultural Marketing Board for the following commodities: maize, potatoes, garlic, ground-nuts, beans, ginger, turmeric etc.

(v) Guaranteed prices by the Mauritius Meat Authority for livestock commodities.

The number of A.D.C's issued from 1982 to 1987 has not followed a regular trend as shown in Figure I. The drastic reduction in the number of A.D.C.'s issued after 1984 may be due to three main reasons which are:

(i) No stable market exists for a large number of commodities. Thus the demand for A.DC..'s to produce those commodities was low.

(ii) Some items, which are produced locally, have been imported at a lower price. Since imports have not been restricted, the demand for A.D.C.'s for those items has decreased.

(iii) A.D.C.'s have not been issued for the production of those items for which self-sufficiency has been reached.

The average production of vegetables, fruits and livestock products for 1985, 1986 and 1987 as a percentage of the target production for these periods have been calculated. The histogram at Figure II illustrates this situation.

It appears that there has been a general increase in production from 1985 to 1986 due to favourable climatic conditions. The situation is reversed for vegetables and fruits from 1986 to 1987. However, livestock production has kept on increasing from 1985 to 1987 as adverse climatic conditions have an insignificant effect on livestock production.

As from 1983, a monitoring unit has been attached to the Division of Land Use and Projects to monitor the progress and development of projects for which A.D.C.'s have been granted. This unit is also responsible for the monitoring of government projects which are funded partly by local and partly by foreign financing agencies.

This paper is made up of two parts. Part A presents the methods adopted by the Division of Land Use and Projects to carry out the technical, financial and economic feasibility studies of agricultural development projects prior to implementation. Part B gives details about the on-going evaluation performed by the monitoring unit.

PART A

FEASIBILITY STUDIES

TECHNICAL FEASIBILITY

Within the technical feasibility study, various aspects of the projects are put to question. For example whether the proposed scale of the project is adapted to the available resources, area or product to be developed and whether the layout and design of the project is the most appropriate. In the case of an irrigation project for instance, technical feasibility involves a careful examination of the availability, quality and reliabiity of an irrigation supply which is essential for sustained and optimum development.

Thus, technical advice is sought from other Divisions of the Ministry before undertaking a technical analysis of a project. For example the technical feasibility study of a livestock development project would require the views of Scientific Officers of the Animal Production Division. In case of projects having missing or misleading information, the project promoter is called upon to give additional explanations.

Before any technical feasibility report is finalised, the objective of the project should be in line with the overall development plan set up by Government. Therefore a project is considered to be technically feasible only when it can be implemented in the best possible area, resources are available for its completion and its objectives are concurrent with Government plans.

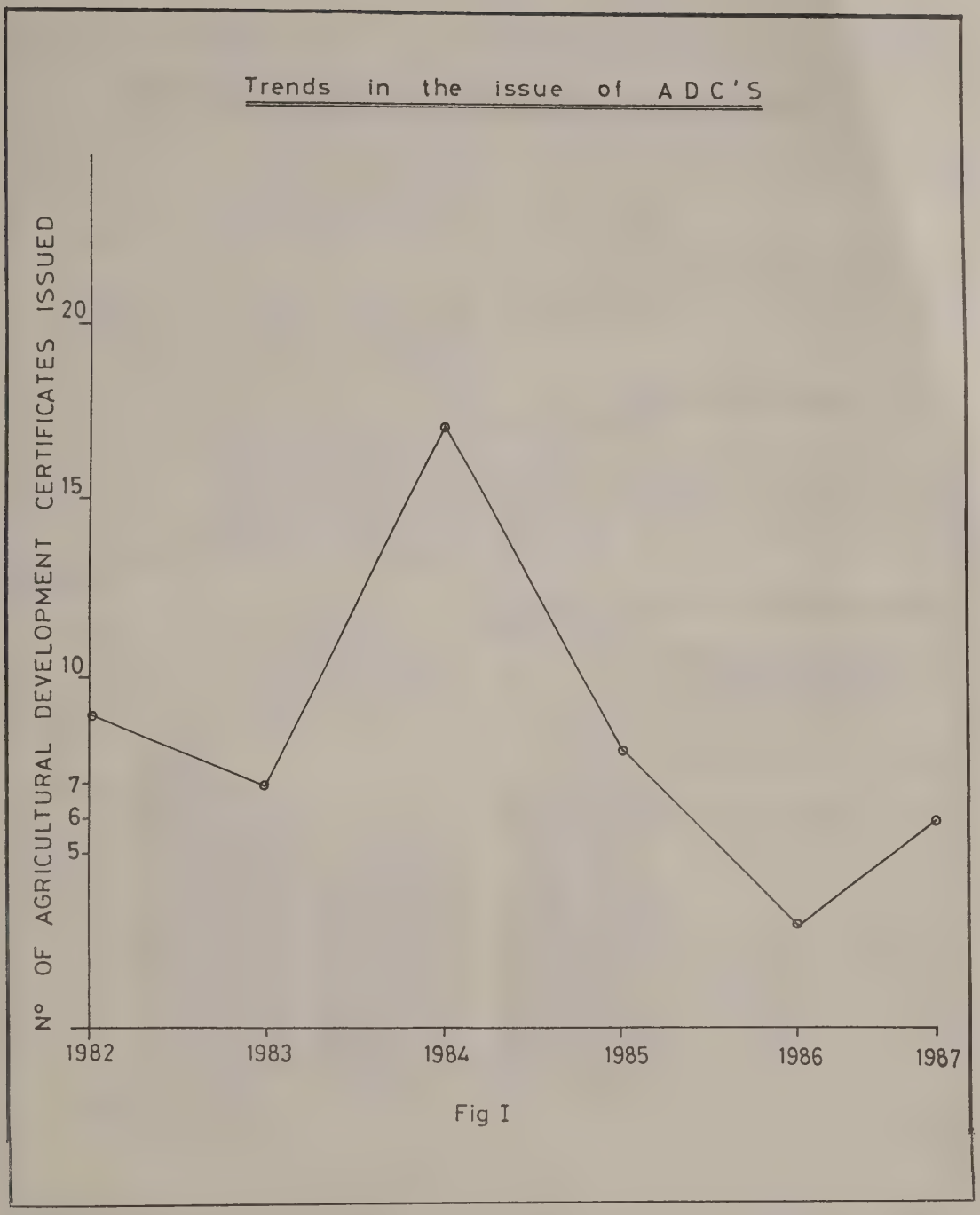
Trends in the issue of A D C 'S
N° OF AGRICULTURAL DEVELOPMENT CERTIFICATES ISSUED
20
15
10
7
6
5
1982
1983
1984
1985
1986
1987

Fig I

Production of vegetables, fruits and livestock

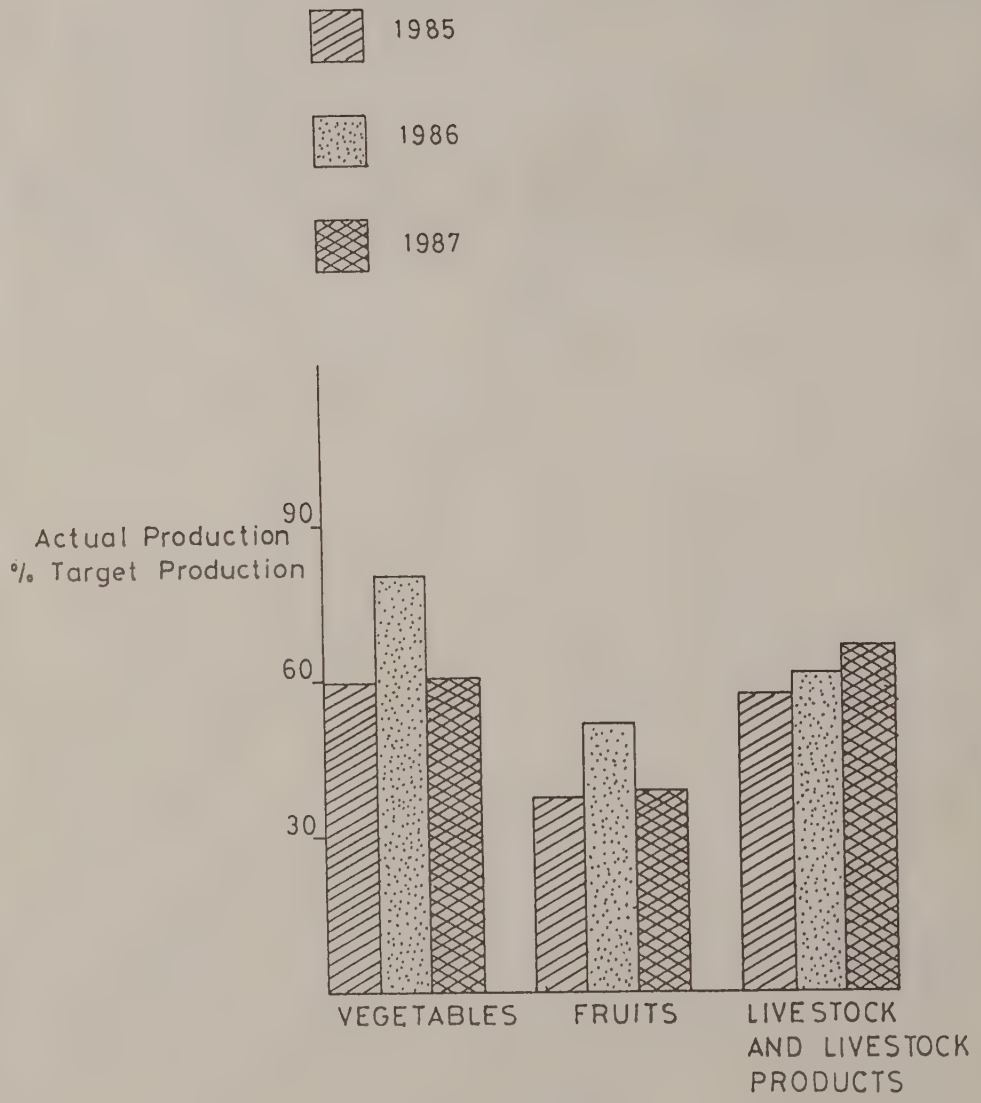

Fig II

FINANCIAL VIABILITY

The benefits and costs estimates presented by the project promoters are scrutinized before any financial analysis is carried out. Very often benefits are exaggerated as the 'without project' situation is overlooked. Realistic values for the benefits are estimated by calculating the difference between the expected production if the project is implemented and what it would have been if the project was not undertaken.

A standard method of financial analysis is used to calculate the rate of return on capital invested in a project. This method has two main variants. In one, namely the benefit-cost ratio, benefits and costs are discounted to their present worth at a discount rate which is equivalent to the average interest rate claimed by most financing agencies (Gittinger, 1982). In the other variant, namely the internal rate of return (or financial rate of return), a discount rate is found at which the present worth of benefits and costs are equal. This discount rate is found by trial and error and by using the equation illustrated in Appendix II.

Only those projects having a benefit-cost ratio above unity are accepted. Furthermore if the financial rate of return of a project is higher than the rate of interest on any loan contracted by the promoter, the project is declared financially feasible.

ECONOMIC FEASIBILITY

In economic feasibility studies projects are examined from a national point of view, that is both direct and social benefits and costs are taken into account. This necessitates the following amendments to the cash flow of the project:—

(i) The prices of imported inputs such as plant and machinery are changed to their C.I.F. values.

(ii) The F.O.B. prices of the outputs are considered.

(iii) The labour costs are valued as the labour's output in its next best use. Furthermore qualified labour is valued higher and unskilled labour lower than the prevailing wage rate.

(iv) The shadow price of land (price of land in its best use in the project area) is used instead of the actual price of land.

After making the above-mentioned modifications in the cash flow of a project, the economic rate of return is calculated in the same way as the financial rate of return.

PART B

THE MONITORING UNIT

INTRODUCTION

Projects are monitored by a team of officers of the Ministry of Agriculture, Fishtries and Natural Resources and of the Monitoring and Project Evaluation Unit of the Ministry of Economic Planning and Development.

COMMON CONSTRAINTS ENCOUNTERED BY PROMOTERS

The visits of the monitoring unit have revealed that several projects fail to reach their target production due to various constraints which are:

(i) Delay in receiving financial assistance

(ii) Delay in obtaining electricity and water supplies

(iii) Disagreement and disputes among shareholders

(iv) Loss of interest by promoters

CONCLUSIONS

Agricultural Development Projects have contri buted towards the creation of more employment. Furthermore there has been a reduction of imports of certain commodities such as onion, garlic, turmeric, beans and live animals.

APPENDIX I

Targets and actual productions in ADC in 1987

Food Crops and Fruits	*Target Production*	*Actual Production*	*%Achieved*
Banana	10,700,000 units	1,668,300 units	16
Beans (pulse)	67 tonnes	30 tonnes	44.8
Garlic	45 tonnes	10 tonnes	22.2
Groundnuts	210 tonnes	54 tonnes	25.7
Maize	1260 tonnes	1482 tonnes	117.6
Mushroom	3 tonnes	0.15 tonnes	0.05
Onion	180 tonnes	40 tonnes	22.2
Pine apple	1,040,000 units	217,392 units	20.9
Potatoes	1,300 tonnes	902 tonnes	69.4
Strawberry	15 tonnes	3 tonnes	20.4
Tomatoes	240 tonnes	43 tonnes	17.9
Livestock and livestock products			
Beef	586 tonnes	525 tonnes	89.6
Broiler Ducks	46 tonnes	42 tonnes	89.7
Honey	41 tonnes	4 tonnes	9.8
Pork	267 tonnes	218 tonnes	81.8
Venison	206 tonnes	33 tonnes	16.2

APPENDIX II

$$FRR = \text{Lower Discount Rate} + \left\{ \text{Difference between Discount Rates} \times \frac{\text{NPV at Lower Discount Rate}}{\text{Change in NPV between Higher and lower rates}} \right\}$$

Where FRR=Financial Rate of Returns

Lower Discount Rate= Rate at which NPV of total benefits just exceeds NPV of total costs.

Higher Discount Rate=Rate at which NPV of total costs just exceeds NPV of total benefits.

NPV=Net present value.

Source: A Manual for Project Appraisal (1980). Ministry of Economic Planning and Development. P 12.

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Contributions are welcome from all research workers within the Ministry and allied Parastatal Bodies. Further details are available from the Secretary c/o Extension Service Division, Réduit, to whom contributions should be addressed.

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